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# Effect of tourniquet use on total blood loss following total knee arthroplasty

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## ABSTRACT

**Objectives:** Blood loss during total knee arthroplasty (TKA) can be a concern. Therefore, a tourniquet (TQ) is commonly used during the procedure to minimize this risk. However, the use of a TQ in TKA continues to be a matter of debate among orthopedic surgeons and is related to its advantages and disadvantages. We retrospectively evaluated the impact of applying the TQ on total blood loss following TKA in 276 patients.

**Methods:** Patients were categorized into two groups: TQ and non- TQ. Demographics, surgical time, pre- and post-operative hemoglobin levels, number of blood units transfused, and rate of venous thromboembolism (VTE) were compared between the groups. The mean age of the study population was 62.8 ± 7.2 years, and 76.4% of patients were females. The TQ group consisted of 159 patients, whereas the non-TQ group consisted of 117 patients.

**Results:** The two groups were homogenous, and there was no statistically significant difference in age or gender distribution between the two groups. The results showed no significant difference in total blood loss, need for blood transfusion, or VTE rate postoperatively when using a TQ. Female gender was identified to be a significant predictor of a decrease in post-operative hemoglobin.

**Conclusion:** We found that the use of the TQ had no effect on total blood loss following primary TKA. Female gender was a predictor of increased blood loss in both groups. It is essential that surgeons performing arthroplasty balance the risks and benefits of using a TQ during TKA.

**Keywords:** Arthroplasty, Blood transfusion, Female, Hemoglobin, Knee replacement, Tourniquet, Tranexamic acid

## INTRODUCTION

Total knee arthroplasty (TKA) is commonly performed to treat patients with knee arthritis. Blood loss during TKA can be a concern. Therefore, a tourniquet is used to minimize the risk of bleeding and any associated complications. Arthroplasty surgeons have different views regarding tourniquet use in TKA. Although an increasing number of surgeons do not use it, it remains common practice to use tourniquets for TKA, despite the risk of local and systemic

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adverse effects. These adverse effects include thigh pain, nerve damage, reactive hyperemia with tourniquet release, altered hemodynamics with limb exsanguination, and delay in neuromuscular recovery.[1,2] Furthermore, there is a potentially higher risk for significant venous emboli dissemination and vascular injury in atherosclerotic arteries and an increase in wound healing disturbances.[3] Moreover, muscle atrophy could occur after TKA; one study reported that atrophy occurred at a rate of 1% per day for the first 2 weeks as a result of tourniquet-induced ischemic reperfusion injury.[4] The proposed advantages of not using a tourniquet in TKA could be lesser post-operative pain, better range of motion, lesser limb swelling, greater strength, and faster recovery.[4-6]

Arthroplasty surgeons use tourniquets mainly to reduce visible and hidden blood loss during TKA, resulting in significant anemia and prolonged post-operative recovery.[7] Moreover, operating in a bloodless field may reduce the operating time, enhance visualization, and improve cement bone fixation. The percentage of hidden blood loss in primary TKA ranges from 30% to 56% of the calculated total blood loss.[8-10] However, multiple studies comparing decreases in post-operative hemoglobin between the tourniquet and non-tourniquet groups showed no significant difference.[11-16] A similar finding was also observed in obese patients, where tourniquet use was not associated with reduced blood loss or increased post-operative complications following TKA.[17] Nevertheless, many reports had demonstrated reduced intraoperative blood loss and total blood loss when tourniquets were used,[18-21] whereas others found increased total blood loss resulting from hemolysis if a tourniquet was used.[22]

This difference in the reported studies could be attributed to many factors, including pre-operative hemoglobin levels, surgical techniques, patient's gender, patient's age, or ethnic group. The main purpose of this study was to assess the total blood loss and need for transfusion following primary unilateral TKA with and without a tourniquet.

## MATERIALS AND METHODS

A cross-sectional study design was conducted to retrospectively review all patients who underwent primary TKA for primary knee osteoarthritis in two institutions from November 2017 to March 2020. Approval was obtained from the institutional ethical boards of the two participating institutions. The study included 276 patients who met the inclusion criteria, who were then categorized into two groups: 159 patients in the tourniquet (TQ) group and 117 patients in the non-TQ (N-TQ) group. Exclusion criteria were specified as simultaneous bilateral TKA; post-traumatic arthritis; previous high tibial osteotomy; rheumatoid arthritis; hemoglobin <10 g/dL; history of venous thromboembolism (VTE); and body mass index (BMI) >40. In addition, the data collected included the patient's age, gender, pre- and post-operative hemoglobin levels, surgical time, post-operative VTE rate, and transfusion data.

### Surgical techniques

All surgeries were performed by tow surgeons who had their fellowship training in the same institute. A standardized surgical technique was used for all patients and performed under spinal or spinal-epidural anesthesia. A midline incision and medial parapatellar approach were utilized for exposure. All patients received intravenous tranexamic acid before incision and the TQ was subsequently inflated. In addition, topical tranexamic acid was applied before closure. Bone cuts and soft tissue balancing were performed in a standardized sequence for all patients. Cruciate substituting TKA prosthetic implants were used for all patients. The average operative time was 90 min.

In the TQ group, the TQ was inflated to 150 mmHg above the systolic blood pressure after elevation and exsanguination of the leg. The TQ was routinely deflated after wound closure, and a compressive dressing was applied. For the N-TQ group, meticulous hemostasis was performed, and active bleeding was stopped with electrosurgical coagulation.

A standardized post-operative management protocol was applied for all patients. All patients received intravenous antibiotic prophylaxis with second-generation cephalosporins. The quantity of intravenous saline administered was unified for all patients as 2000–3000 mL/24 h. Hemoglobin levels were routinely checked for all patients 24 h postoperatively, and the transfusion trigger was hemoglobin levels <9 g/dL associated with clinical symptoms. All patients received standard thromboprophylaxis with low molecular weight heparin and compressive stockinette. Early mobilization was performed in the first 24 h postoperatively for all patients.

The primary outcome was to assess the decrease in hemoglobin levels in the TQ group compared to that in the N-TQ group. The secondary outcome was to compare the need for blood transfusion and VTE events between the two groups. In addition, we evaluated the impact of patient's gender and age on the decrease in hemoglobin levels.

### Statistical analysis

Statistical Package for Social Science (SPSS) version 24.0 software (IBM SPSS Statistics for Windows, Armonk NY: IBM Corp), was used to perform all analyses, and the following tests and techniques were used according to the type of data. Descriptive data are expressed as frequency, percentage, mean, and standard deviation. Continuous data with normal distribution were expressed as means (± standard deviations) and abnormally distributed data as

medians (ranges). Kolmogorov–Smirnov and Shapiro–Wilk tests were used to assess data distribution for normality. Student's *t*-test was used for comparison of continuous data when the data appeared to be normally distributed and Mann–Whitney U test was used to compare the rates of blood transfusion in the two groups. $P < 0.05$ was considered statistically significant.

## RESULTS

Two hundred and seventy-six patients were enrolled in this study. The mean age of the study population was 62.8 ± 7.2 years, and 76.4% of patients were females. Demographic data showed that the N-TQ group consisted of 117 patients, 77.8% of whom were females. The mean age of the N-TQ group was 63.3 ± 6.6 years, and 74.4% of them were aged ≥60 years. By contrast, the TQ group consisted of 159 patients, and 75.5% of them were females. The mean age of the TQ group was 62.5 (±7.6) years, and 61.0% were aged ≥60 years [Table 1]. The two groups were homogenous, and there was no significant difference in the age distribution ($P = 0.342$) or gender distribution ($P = 0.655$) between the groups [Table 1]. In addition, there were no significant differences in the pre-operative hemoglobin levels between the groups [Table 2].

The mean decrease in hemoglobin levels in the N-TQ group was 1.16 g/dL (±0.93) compared to 1.44 g/dL (±0.80) in the TQ group, with no statistically significant differences in post-operative hemoglobin levels between both groups ($P = 0.907$), [Table 2]. Moreover, three patients received blood transfusion in each group, and there was no statistically significant difference in blood transfusion need between the two groups [Table 3].

To study the impact of age on hemoglobin drop postoperatively, we compared post-operative hemoglobin drop in patients aged ≥60 years to patients aged <60 years and found no statistically significant differences in both groups [Table 4]. However, we found that the female gender was a predictor factor for post-operative hemoglobin reduction compared to the male [Table 5].

## DISCUSSION

TKA is an operation successfully used to relieve pain and improve mobility in patients with end-stage osteoarthritis. However, the outcome is influenced by many factors.[23-25] We found that using a TQ in primary TKA did not affect total blood loss postoperatively. Orthopedic surgeons are accustomed to using TQ in TKA to minimize intraoperative blood loss despite the contradictory results in the literature. Although TQ use has many proposed advantages, such as operating in a bloodless field and better cement bone fixation, many drawbacks of using it may impact the outcome.[26,27] The ischemic condition caused using a TQ may lead to sustained local reactive hyperemia for several hours following TQ release. This hyperemic response could lead to more bleeding into the traumatized tissue postoperatively.[28,29] In addition, the increased fibrinolytic activity associated with TQ-induced ischemia may promote local post-surgical bleeding.[22,28,30] Nevertheless, some authors suggested that it could be controlled after the application of wound pressure dressing.[31,32] Li *et al.* found that the extent of hemo-cytolysis was more serious with a TQ and concluded that using a TQ in TKA may promote post-operative hidden blood loss and delay rehabilitation exercises.[8] Some studies proposed using limb occlusion pressure (LOP) instead of the conventional method to estimate occlusion pressure to minimize the post-operative complication of TQ uses.[33,34] However, they found that LOP methodology helps in reducing thigh pain and swelling without impact on the surgical field visualization or amount of blood loss.

Studies found that the need for transfusion could be reduced when using TQs.[35,36] However, our results showed that there was no significant difference in the need for blood transfusion postoperatively with or without TQ use, consistent with the findings of other studies.[18,19,37] The need for blood transfusion in our study was minimal compared to findings of other published reports.[38,39] This finding could be related to pre-operative optimization of patient conditions, such as hemoglobin levels, use of tranexamic acid, and our high threshold for transfusing patients based on post-operative clinical and laboratory findings. Some authors found that low pre-operative hemoglobin, long operative time, BMI more than 30, and general anesthesia were major predictors of blood transfusion needs after TKA.[40-42] TQ use was reported to be associated with a higher risk of developing VTE complications following TKA.[43] However, our results showed no difference in the incidence of thromboembolism complications with or without TQ use. This finding was

**Table 1:** Patient demographic data.

| Group | *n* | Age | | Age distribution | | | | Sex distribution | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Age (y) | *P*-value | ≥60 | % | <60 | % | Male | % | Female | % | *P*-value |
| N-TQ Group* | 117 | 63.3 (±6.6) | 0.342 | 87 | 74.40 | 30 | 25.60 | 26 | 22.20 | 91 | 77.80 | 0.655 |
| TQ Group** | 159 | 62.5 (±7.6) | | 97 | 61.00 | 62 | 39.00 | 39 | 24.50 | 120 | 75.50 | |
| Total | 276 | 62.8 (±7.2) | -- | 184 | 66.60 | 92 | 33.40 | 65 | 23.60 | 211 | 76.40 | -- |

*TQ Group: Tourniquet group, **N-TQ Group: Non-Tourniquet group

**Table 2:** Comparison of pre- and post-operative hemoglobin levels between the two groups.

| Group | *n* | Pre-operative HB* | *P*-value | Post-operative HB | *P*-value | HB decrease | *P*-value |
|---|---|---|---|---|---|---|---|
| N-TQ Group | 117 | 12.8 (±1.4) | 0.111 | 11.6 (±1.4) | 0.324 | 1.16 g/dL (±0.93) | 0.907 |
| TQ Group | 159 | 13.1 (±1.3) | | 11.6 (±1.5) | | 1.44 g/dL (±0.80) | |

*HB: Hemoglobin

**Table 3:** Need for blood transfusion in total knee arthroplasty between the TQ and N-TQ groups.

| Dependent variable | Groups | *n* | Rate (%) | *P*-value |
|---|---|---|---|---|
| Blood transfusion incidence | N-TQ Group | 3 | 2.60 | 0.703 |
| | TQ Group | 3 | 1.90 | |
| Thromboembolism incidence | N-TQ Group | 1 | 0.90 | 0.456 |
| | TQ Group | 1 | 0.60 | |

TQ: Tourniquet, N-TQ: Non-tourniquet

**Table 4:** The differences in hemoglobin level postoperatively between patients categorized according to age (<60 years and≥60 years) with and without TQ use.

| Hemoglobin level | Age (years) | n | Mean | *P*-value |
|---|---|---|---|---|
| N-TQ Group | <60 | 30 | 11.3 (±1.4) | 0.145 |
| | ≥60 | 87 | 11.8 (±1.4) | |
| TQ Group | <60 | 62 | 11.5 (±1.3) | 0.385 |
| | ≥60 | 97 | 11.7 (±1.5) | |

TQ: Tourniquet, N-TQ: Non-tourniquet

**Table 5:** The differences in hemoglobin level between men and women (post-operative patients) with and without TQ use.

| Hemoglobin level | Gender | *n* | Mean | *P*-value |
|---|---|---|---|---|
| N-TQ Group | Male | 26 | 12.5 (±1.6) | <0.0001 |
| | Female | 91 | 11.4 (±1.2) | |
| TQ Group | Male | 39 | 12.3 (±1.3) | <0.0001 |
| | Female | 120 | 11.4 (±1.4) | |
| All patients | Male | 65 | 12.4 (±1.4) | <0.0001 |
| | Female | 211 | 11.4 (±1.3) | |

TQ: Tourniquet, N-TQ: Non-tourniquet

consistent with those of other studies showing no difference in VTE events between the groups.[19,44] In our opinion, orthopedic surgeons need to consider balancing the risks and benefits of using a TQ during TKA. Our study results support previous findings, which showed that TQ s use have no effect on minimizing total blood loss following TKA. Zhang *et al.* conducted a systematic review and showed no significant differences between the two groups in terms of actual blood loss.[45] Tarwala *et al.* suggested that no significant clinical differences existed between patients who had a TQ inflated throughout the procedure compared with those who had it inflated only during cementation.[46] However, the only benefit of TQ inflation during cementation is to help the surgeon working in a bloodless field for better bone fixation and reduce the risks associated with the prolonged TQ application.[26,46] Although the use of TQs has many advantages, not using TQs also has many advantages, including lesser use of pain killers, better early range of motion, and earlier straight leg raising.[5,47] However, these minor complications did not impact post-operative recovery in either group.[5,48]

The timing of TQ release is an important issue that needs to be considered. Although releasing a TQ before wound closure may increase total blood loss and operative time, meticulous hemostasis can lower the risk of complications.[49] Therefore, releasing TQ s before wound closure to reduce the risk of complications would not be an appropriate decision. A similar conclusion drawn from a meta-analysis demonstrated that the total blood loss when the TQ was deflated before wound closure was significantly higher than when the TQ was deflated after wound closure.[50]

Regarding the gender prediction of increased blood loss following TKA, our results showed that the female gender is a predictor of higher total blood loss, with or without the use of a TQ. However, this was not reflected in the need for blood transfusion in females. This finding was contradictory to other studies, where the male gender was found to be a predictor of increased total blood loss following TKA.[9,47,48] However, some studies found no differences in total blood loss between males and females.[38] This finding might be attributed to the different ethnicities of the patients in these studies.

We acknowledged that our study had some limitations to be considered. The presented work retrospectively analyzed the effect of TQ use in TKA and its impact on total blood

loss postoperatively. Due to this retrospective collection of data, we could not identify specific criteria defining the basis of using a TQ or not. However, we believe that the finding of this study can be used as supporting evidence that would encourage arthroplasty surgeons to reconsider this practice. In addition, we could not study other factors, such as pain score, muscle strength, need for narcotics, or other functional scores because of the lack of uniformity in recording such factors between the centers.

## CONCLUSION

Using a TQ during TKA does not affect post-operative hemoglobin levels, the need for blood transfusion, or the incidence of deep vein thrombosis and pulmonary embolism following TKA. Female gender was found to be a predictor of increased blood loss following TKA with and without TQ use. Therefore, arthroplasty surgeons must weigh the risks and benefits of using a TQ during TKA.

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## AUTHORS' CONTRIBUTIONS

KHA: Conceptualized the idea, study design, data collection, analyzing and interpretation of the data, and drafted the first manuscript, critical review of the final manuscript. ASA: Conceptualized the idea, study design, data collection, data analysis, and drafted the first manuscript. MMT: Provided critical supervision during the writing of the manuscript, critical review of the final draft. AME: Data collection, critical review during the writing of the manuscript. ANA: Provided critical supervision during the writing of the manuscript, critical review of the final draft. All authors participated in the writing of and made essential contributions to this paper and critically reviewed and approved the final manuscript.

## ETHICAL APPROVAL

This study was approved by the Institutional Review Board at King Abdullah Medical City (Study number: 20-639) on June 11, 2020 and by the Institutional Review Board at Security Forces Hospital (IRB approval number: 0379-03092) on September 15, 2020.

### Declaration of patient consent

Both IRBs exempted the study from obtaining individual subject consent, provided that patients' data be anonymous. Therefore, the data was only accessible to the authors and was password protected. Information that might identify the patients such as names and medical record numbers (MRNs) was not collected. A serial number was given to the patients to replace MRNs.

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### Conflicts of interest

There are no conflicts of interest.

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